

REMARKS

By the present amendment, claims 1 to 8 are pending in the application.

Claims 1 and 2 are independent claims.

Claim Amendments

Claim 1

In claim 1, the limitation --TiAl₃-- is supported by prior, now canceled, dependent claim 5.

Claim 2

In claim 2, the limitation --Ti (Al_{1-x} Si_x)₃ where x = 0 to 0.5-- is supported by prior, now canceled, dependent claim 6.

Claims 7 and 8

Dependent claims 7 and 8 have been amended to conform their dependencies to the amended claims.

Claim Objections

Claim 3 was objected to because it was a duplicate of claim 3.

In response to this objection, claim 3 has been canceled by the present amendment.

In view of the present amendment, it is respectfully requested that the objection to claim 3 be withdrawn.

§102/§103

Claims 1 to 8 were rejected under 35 U.S.C. §102(b) as being anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over Japan No. 2002-187234 to Fumishiro et al. (English machine translation).

Claims 1 and 5 to 8 were rejected under 35 U.S.C. §102(b) as anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over WO 98/26103 to Komatsu et al.

These rejections, as applied to the amended claims, are respectfully traversed.

The Present Invention

A characteristic feature of the present invention is that a highly corrosion-resistant hot-dip galvanized steel product excellent in surface smoothness and formability, has on the steel product surface a zinc alloy plating layer composed of 4 to 22% by mass of Al, 1 to 5% by mass of Mg, up to 0.1% by mass Ti, up to 0.5% by mass of Si and a balance of Zn and unavoidable impurities, wherein the plating layer of the plated steel product has a metal structure in which an [Mg₂Si phase], an [Al phase] and a [Zn₂Mg phase] are present in a mixture in the matrix of an [Al/Zn/Zn₂Mg ternary eutectic structure], and the plating layer contains a Ti-Al base intermetallic compound in one or more of the [Al phase], [Zn₂Mg phase] and [Zn phase]. That is, a Ti-Al base intermetallic compound must be contained in one or more of the [Al phase], [Zn₂Mg phase] and [Zn phase] for obtaining good surface smoothness and formability.

Patentability

The technology disclosed in JP 2002-187234 (‘234 patent) relates to a non-Cr coated steel sheet comprises a galvanized layer containing Al: 4 - 20%, Mg: 1 - 4%, Ti: 0 - 0.1%, B: 0 - 0.045%, Si: 0 - 0.5%, an organic-inorganic compound film containing a Ti compound, a fluorine article, and an organic resin, and a coating film not containing Cr to be successively layered on the surface of the base steel sheet.

The Ti compound contained in the organic-inorganic compound film is 1 - 100 mg/m² as a coating weight in terms of Ti. The fluorine article is 1 - 200 mg/m² as a coating weight in terms of fluorine. The organic-inorganic composite film can further

contain a Zr compound of 0.1 - 30 mg/m² as a coating weight in terms of Zr. However, the '234 patent does not disclose or suggest Ti-Al intermetallic compound.

Further, the '234 patent only describes a "Ti and B containing Zn - Al coating bath is used to restrain Zn₁₁Mg₂ phase formation and growth". There is no disclosure or suggestion about a dispersion of Ti-Al intermetallic compound having the size of less than 10 μ m in the plating bath. Further, the '234 patent describes in the embodiment that the coating layer is composed of a mixture of proeutectic Al phase or proeutectic Al phase and Zn single phase in the matrix of [Al/Zn/Zn₂Mg] ternary eutectic structure, and a Zn₂Mg phase or Zn single phase existing at the circumferential area of retained precipitates are primary etched. From these statements, it is believed that Ti-Al, Ti-B and/or Al-B precipitates is (are) exist in the matrix of the ternary eutectic structure. Because, in the coated layer in the '234 patent, the Zn₂Mg phase exists only in the matrix of the ternary eutectic structure, and this description only explains that the precipitate exists in the matrix of the ternary eutectic structure.

Therefore, the technology disclosed or suggested in the '234 patent is quite different from the present invention in the points of a production process, coated layer, the object of the addition of additives, and effects.

The technology disclosed in WO 98/26103 ('03 patent) relates to a hot-dip Zn-Al-Mg coated steel sheet excellent in corrosion resistance and surface appearance, where the steel sheet has a coating layer which is formed by hot dipping and which contains 4.0 - 10 wt% of Al, 1.0 - 4.0 wt% of Mg, optionally contains Ti: 0.002 - 0.1 wt%, B: 0.001 - 0.0045 wt%, and the balance being Zn. The coating layer has a metallic structure in which a [proeutectic Al phase] or both of a [proeutectic Al phase] and a [single Zn phase] are dispersed in a matrix of an Al/Zn/Zn₂Mg ternary eutectic structure.

The coating layer of the '103 patent having such a metallic structure can be formed by properly controlling the rate of cooling of the coating layer adhering to the steel strip pulled up from a plating bath in continuous plating equipment and the temperature of the plating bath and/or by adding proper amounts of Ti and B into the plating bath. The streaking inherent in such a coated steel sheet is inhibited by controlling the configuration of a Mg-containing film generated until the solidification of the coating layer or by the addition of a proper amount of B into the plating bath.

However, the '103 patent does not disclose or suggest anything about a Ti-Al base intermetallic compound and that this Ti-Al base intermetallic compound must be contained in one or more of the [Al phase], [Zn₂Mg phase] and [Zn phase] for obtaining good surface smoothness and formability. In addition, this Ti-Al base intermetallic compound cannot be confirmed from Figs. 1 to 4 of the '103 patent. The '103 patent further discloses that Ti, B or the TiB₂ phase cannot be clearly observed by an electron microscope in the secondary electron image in the low amount of Ti and B such as in the '103 patent, and the metallic structure is substantially the same as the plated steel sheet without containing Ti and B. Therefore, it is clear that the '103 patent does not contain a Ti-Al intermetallic compound in the plated layer. In addition, the '103 patent further stated that if the Ti content exceeds 0.1 wt%, Ti-Al precipitates grow and cause an uneven surface appearance.

On the other hand, the present invention aims to refine the crystals of the plated layer structure as nucleus of a fine Ti-Al intermetallic compound for reducing the surface unevenness caused by the different size of crystals. Therefore, the present invention is clearly different from the '103 patent. The reason to limit the feature "Ti-Al base intermetallic compound must be contained in one or more of the [Al phase], [Zn₂Mg phase]

and [Zn phase]" is that the Ti-Al base intermetallic compound existing at the outside of the [Al phase], [Zn₂Mg phase] and [Zn phase] cannot improve the surface smoothness and formability, as mentioned in the specification of the present application.

The present inventors discovered that Ti-Al base intermetallic compound is contained in one or more of the [Al phase], [Zn₂Mg phase] and [Zn phase] for refining the crystals of the plated layer structure as nucleus of a fine Ti-Al intermetallic compound for reducing the surface unevenness caused by the different size of crystals. More concretely, the required plated steel sheet can be obtained if the amount of Ti-Al intermetallic compound exists at more than 10% among the [Al phase], [Zn₂Mg phase] and [Zn phase]. Further, in case of the present invention, Ti-Al intermetallic compound is clearly observed by an electron microscope in the secondary electron image as shown in Figs. 1 and 2 of the present application.

The reason to define the amount of Ti-Al intermetallic compound existing at more than 10% among [Al phase], [Zn₂Mg phase] and [Zn phase] is that the refined crystals by the Ti-Al intermetallic compound as a nucleus inhibits the growth of other circumference crystals. If the amount of Ti-Al intermetallic compound is less than 10%, crystals can be grown larger during a solidification of the remained plating bath because the number of refined crystals are too small in the plated layer. Therefore, an uneven surface appearance is formed caused by different sizes of the crystals and a smooth surface cannot be obtained. However, it is necessary to disperse uniformly the refined Ti-Al intermetallic compound of more than 10% in either one of the [Al phase], [Zn₂Mg phase] or [Zn phase].

The specific gravity of the Ti-Al intermetallic compound is half of that of the plating bath. Therefore, the Ti-Al intermetallic compound floats on the plating bath.

Therefore, it is necessary to refine the size of the Ti-Al intermetallic compound to less than 10 μm for suspending in the plating bath. This is because buoyancy is

proportionate to volume and the resistance of movement of the Ti-Al intermetallic compound into the plating bath is proportionate to cross-sectional area. Therefore, a small size for Ti-Al intermetallic compound is difficult to float and is suspended for a long time in the plating bath. If the size of Ti-Al intermetallic compound exceeds 10 μm , it easily floats on the plating bath in few seconds and is difficult to disperse uniformly.

Therefore, it is necessary to disperse the refined Ti-Al intermetallic compound having less than 10 μm size in the plating bath.

A coarse size for the Ti-Al intermetallic compound sticks on the plating surface and cause the surface defects, such as uneven surface appearance. The '103 patent describes that this defects remarkably occurs if the Ti content exceeds 0.1 wt% in the plating bath. However, the defects are caused even if the Ti content is less than 0.1 wt% in case of Ti-Al intermetallic compound floating on the plating bath. For avoiding such defects, it is necessary to disperse uniformly the refined Ti-Al intermetallic compound of more than 10% as a powder state in either one of the [Al phase], [Zn₂Mg phase] or [Zn phase], or it is necessary to dissolve Ti as a supersaturation for crystallizing as Ti-Al intermetallic compound in the plating bath and start solidification before the Ti-Al intermetallic compound forms a coarse size, such as more than 10 μm .

Further, the '103 patent discloses "it is necessary to use the plating bath added appropriate amount of Ti and B to the basic components" as a method of adding Ti and B, and further discloses "it can be used Ti, B and/or TiB₂ as additives, and it can be existed as TiB₂ in the plating bath containing Ti and B". However, the '103 patent does not disclose or suggest the dispersion of Ti-Al intermetallic compound having the size of not more than 10 μm . As a result, the '103 patent is quite different from the present invention in the points of no Ti-Al intermetallic compound in the plating bath, in addition to the production process and the construction of the plating layer.

The '103 patent further describes regarding the Ti and B addition that "forming Zn₁₁Mg₂ phase and restraining growth, and stably grow Zn₂Mg phase". This statement is quite different from the technical idea of the present invention.

Summary

As clearly understood from the '103 patent and '234 patent, it is difficult for Ti-Al intermetallic compound to exist in either one of [Al phase], [Zn₂Mg phase] or [Zn phase] of more than 10% in the plating layer, because the amount of Ti concentration dissolved in the coating bath is very small considering the coating bath components disclosed in the '103 patent and '234 patent, and most of Ti exists only as a Ti-intermetallic compound in the coating bath. Both of these references only describe a Ti and B addition into the coating bath, and there is no description as to what metal or what compound is added to the coating bath in addition to no description as to how Ti or B exists in the coating bath. The specific gravity of this Ti-intermetallic compound is smaller than that of the coating bath and floats on the plating bath. A small size of this compound exists in the matrix and a coarse size of this compound forms uneven surface appearance.

The '103 patent and the '234 patent do not disclose or suggest the characteristic feature of the present invention of uniformly dispersing the refined Ti-Al intermetallic compound of more than 10% in either one of [Al phase], [Zn₂Mg phase] or [Zn phase], that it is necessary to dissolve Ti as supersaturation for crystallizing as Ti-Al intermetallic compound in the plating bath and solidification starts before Ti-Al intermetallic compound forms a coarse size, such as more than 10 μm .

In these references, there is no disclosure or suggestion about how Ti-Al intermetallic compound exists in the coating bath or a uniformly dispersion of refined Ti-Al intermetallic compound having the size of not more than 10 μm in the coating bath.

In accordance with the present invention, a Ti-Zn intermetallic compound is added to Zn-Al-Mg plating bath or Zn-Al-Mg-Si plating bath for desolving in supersaturated state. A Ti-Al intermetallic compound exists at more than 10% in either one of the [Al phase], [Zn₂Mg phase] or [Zn phase] in the plating bath. This feature is not disclosed or suggested in either the '103 patent or the '234 patent.

Summarizing the above mentioned statements, the present inventors discovered that when Ti-Al intermetallic compound is added to the Zn-Al-Mg plating bath or Zn-Al-Mg-Si plating bath, dissolved Ti contained in Ti-Al intermetallic compound reacts with Al contained in the plating bath and forms a refined Ti-Al intermetallic compound. This reaction is a plural non-equilibrium reaction, and this reaction cannot be conceived of from a Zn-Ti binary equilibrium reaction taught by the '234 patent, even if both of the '103 patent and '234 patent are combined.

Further, in the present invention, it is possible to provide a highly corrosive-resistant hot-dip galvanized steel product excellent in surface smoothness and formability, having on the steel product surface a zinc alloy plating layer composed of 4 to 22% by mass of Al, 1 to 5% by mass of Mg, up to 0.1% by mass Ti, up to 0.5% by mass of Si and the balance of Zn and unavoidable impurities, the plating layer of the plated steel product having a metal structure in which an [Mg₂Si phase], an [Al phase] and a [Zn₂Mg phase] are present in a mixture in the matrix of an [Al/Zn/Zn₂Mg ternary eutectic structure], and the plating layer containing a Ti-Al base intermetallic compound in one or more of the [Al phase], [Zn₂Mg phase] and [Zn phase].

It is therefore submitted that independent claims 1 and 2, and all claims dependent thereon, are patentable over Japan No. 2002-187234 and/or WO 98/26103 standing alone or in combination.

CONCLUSION

It is submitted that in view of the present amendment and the foregoing remarks, the application is now in condition for allowance. It is therefore respectfully requested that the application, as amended, be allowed and passed for issue.

Respectfully submitted,

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